

REMARKS

Applicants have now revised the application in consideration of the Examiner's comments and observations set forth in the Office Action of March 29, 2002. Reexamination and reconsideration are respectfully requested.

The Office Action

Various objections to the drawings were issued in the Office Action. These objections have been addressed in the accompanying request for amendment to drawings and through amendments to the specification. It is submitted the objections to the drawings based on these changes have been fully addressed.

The Specification Was Rejected Due to Typographical Consideration, Which Has Also Been Addressed

Claims 1-15 were presented for examination.

Claims 2 and 4-15 were rejected under 35 U.S.C. § 112, second paragraph.

Claims 1-5 stand rejected as being anticipated by Dhuler, et al. (U.S. Patent No. 5,962,949).

Claims 6-15 were noted to contain allowable subject matter for the primary reason that the prior art does not show the currently claimed combinations.

The Non-Art Rejections

Claims 2 and 4-15 have been reviewed and were appropriately amended to address the rejections under 35 U.S.C. § 112, second paragraph. It is submitted the claims as now set forth are proper under this paragraph. It is also noted by Applicants that the changes herein are not related to patentability but to improving the understanding of the claims, and the changes are no more than what is inherently set forth in the originally-submitted claims. Particularly, the use of "the out-of-plane device" in various ones of the claims has been amended to recite a "micro-device" for a more consistent use of language. Applicants have also amended other claims to provide the antecedent basis which would be appropriate.

The Art Rejections

As previously noted, claims 6-15 were noted to contain allowable subject matter. In view of the amendment to various ones of these claims, where appropriate, to address the 35 U.S.C § 112 sections, it is submitted these claims are now in condition for allowance.

Attention is now directed to claims 1-5. Claim 1 stands rejected as being anticipated by Dhuler, et al. ('949). The first layer 52 of Dhuler, et al. and the second layer 54 of Dhuler, et al. are pointed to as being equivalent to the "ribbon hinge structure" of claim 1. A heater 56 is pointed to as being equivalent to the "electrical conductor" of claim 1. As disclosed in column 7 beginning on line 44 through column 8, line 46, the second layer 54 is formed of material having a lower or smaller coefficient of expansion than the material forming the first layer. Heater 56 is disposed between the first and second layers. By passing current through the heater, the heater heats the first and second layers which expand at different amounts so as to cause the Z-actuator to bend. Thus, the concept of Dhuler, et al. as cited by the Office Action is to sandwich the heater 56 between two deformable layers. The heater is then provided with energy which causes expansion at varying rates permitting movement of the actuator 50. On the other hand, the electrical conductor of the present application is defined as being carried on at least a portion of a surface of the ribbon hinge structure. Particularly, as shown in the figures, the electrical conductor 57 is not sandwiched between two layers as specifically cited in Dhuler, et al. Particularly, a device formed in accordance with the limitations of claim 1 would not operate in the intended manner as set forth in Dhuler, et al. Particularly, as there is no limitation of having the electrical conductor carried between two layers having distinct coefficients of expansion, providing current or power to the electrical conductor of the present application would not provide the bending function as clearly called for in the cited patent. Further, different methods of design would be required to build and construct the design set forth in claim 1 as opposed to the device of Dhuler, et al.

For this reason, it is noted claim 1 is distinguished from the cited reference.

Applicants note that as claims 2-5 depend from and further describe the subject matter of claim 1, these claims are also distinguished. Further, with respect to dependent claims 3, 4 and 5, while Dhuler, et al. does talk about movement in the X, Y and Z position, it is respectfully submitted this does not address movement in a twisting mechanical torque or rotational design. Rather, while movement in the X and Y position are in the same plane, movement in the Z position is nevertheless a forward and back movement but not a twisting movement as described in claim 3 as well as dependent claim 14.

With attention to claim 5, Applicants have reviewed claim 4, and submit the figure does not teach specifically having a ribbon hinge structure which has at least a width or

thickness less than a width or thickness of the micro-device.

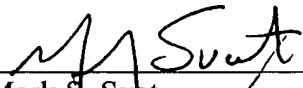
For the foregoing reason, it is respectfully submitted claims 1-5 are distinguished from the cited art. Applicants have reviewed the cited but not applied reference and do not find these more pertinent than the applied reference. However, Applicants will not burden the record with a full discussion of these references.

New claims 16, 17 and 18 have been drafted to provide additional concepts to independent claims 1 and 6. It is submitted these additional concepts are not taught or fairly suggested by the reference, including having the ribbon hinge structure to include an anchor portion with an isolation groove and the ribbon hinge having an isolation region into which is deposited the electrical conductive material. Further, claims 17 and 18 provide additional structure for independent claim 7 not taught or fairly suggested by the references.

CONCLUSION

For the reasons detailed above, it is respectfully submitted all claims (claims 1-18) are now in condition for allowance. An early notice to that effect is therefore earnestly solicited.

Respectfully submitted,
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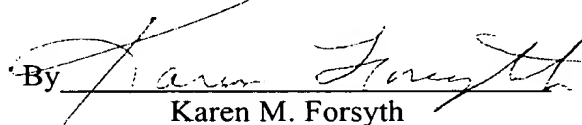


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Attachment: Version With Markings to Show Changes Made

CERTIFICATE OF MAILING

I hereby certify that this Amendment A is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Assistant Commissioner of Patents and Trademarks, Washington, D.C. 20231, on **July 1, 2002**.

By 

Karen M. Forsyth

VERSION WITH MARKINGS TO SHOW CHANGES MADE**In the Specification**

Please insert the following new paragraph after "Background of the Invention" and before the first full paragraph on page 1, as follows:

The U.S. Government has a paid up license in this invention and the right in limited circumstances to require the patent owner to license others on reasonable terms as provided for by the terms of Contract No. 70NANB8H4014 awarded by NIST.

Please amend the second full paragraph on page 1 as follows:

The use of micro-hinges has become prevalent with the increased utilization and complexity of surface micro-machined components and systems. Typically used in the implementation of out-of-plane or vertically oriented micro-device designs, the micro-hinge is usually fabricated in a minimum two-layer, though typically three-layer, polysilicon process. Such a hinge, known as a staple hinge 10, is illustrated in FIGURE 1 integrally connected with micro-mirror 12, and is used to attain out-of-plane motion. The multi-step fabrication process, includes depositing a layer which is then patterned and etched. Next a second layer is deposited, patterned and etched in such a way that after removing any filling material, the first layer is free to move in a prescribed path, while being held in place by the second layer. This structure creates a rotating joint implemented in MEMS or micro-systems to permit for the mechanical movement required for out-of-plane or vertically oriented devices.

Please amend the first full paragraph on page 2, under "Summary of the Invention" as follows:

Provided is a micro-electromechanical assembly including a micro-device formed in the device layer of a silicon-on-insulator substrate. A ribbon structure is formed in the same device layer, where the ribbon structure is less than the thickness of the micro-device. A connection interface provides a connection point between a first end of the micro-device and

a first end of a ribbon structure, wherein the ribbon structure and micro-device are integrated as a single assembly. An electrical conductor is formed extending from [on] one end of the ribbon structure to the micro-device tethered at the other end.

Please amend the paragraph on page 3 under "Detailed Description of Preferred Embodiments" as follows:

While Figure 1 depicts a micro-assembly implementing a polysilicon staple/door-hinge, FIGURES 2 and 3 illustrate a micro-assembly 18 having a ribbon hinge 20 integrated with micro-device 22, such as a micro-mirror. The micro-mirror device 22 has been moved from an in-plane position to an angle of approximately 30°. Particularly, the ribbon hinge structure is configured with a mechanical integrity which permits application of a side-twisting mechanical torque sufficient to twist the ribbon hinge structure to 90° or more from an initial 0° twisted position. Movement of the mirror is achievable by a variety of mechanisms, including the use of a micro-probe or an actuator.

Please amend the first full paragraph on page 7 as follows:

Following removal of first photo-resist layer 40, second resist layer 48 is applied on the top surface of SOI 30. In step 50, a dry etching process is undertaken on the exposed silicon of device layer 32 to form the out-of-plane micro-device 52, as well as the island area 54, anchor structure 56 and isolation region or groove 57.

Please amend the second full paragraph on page 7 as follows:

Turning to FIGURE 5, set forth is a top view of step 58 of FIGURE 4. Ribbon hinge 42 is shown connected to anchor portion 56 at a first end and to micro-device 52 at a second end. Patterned within micro-device 52 is [an] isolation region 57. As will be discussed in greater detail below, isolation region 57 is patterned within micro-device 52 to isolate an electrical conductor to be deposited therein, from the remainder of micro-device 52. It is to be appreciated that an isolation groove may also be patterned within the ribbon structure 42 and anchor 56. The additional areas where isolation grooves may be etched are shown in FIGURE 6, which may be considered a further embodiment of the etching process shown in FIGURE 4. Herein, two isolation regions 57A and 57B are

etched into micro-device 52. Isolation regions 57C and 57D are also to be etched within ribbon structure 42 through anchor 56. FIGURE 6 emphasizes that multiple conductor lines may be processed on a single ribbon hinge 42 and/or micro-device 52. It is also to be understood that multiple ribbon hinges may be attached to a single micro-device.

Please amend the second full paragraph on page 8 as follows:

Once electrical conductive material 65 has been deposited, the buried oxide release (BOX) operation is undertaken, whereafter, as shown in step 66 of FIGURE 4, the only remaining buried oxide layer material 68 and 70 is under the island structure 54 and the anchor section 56. The remaining buried oxide material is removed such that a separation layer 72 and separation edge 74 are void of such material. Removal of the buried oxide allows for the movement of the micro-device 52 and ribbon hinge 42. In step [68]66, it is noted that all remaining photo-resist is removed, for example, by a dry O₂ plasma-etch process.

Please amend the third full paragraph on page 8 as follows:

Thus, step [68]66 depicts the original SOI wafer 30 as a micro-device and hinge assembly, with a conductor.

Please amend the paragraph beginning on page 8 and continuing onto page 9 as follows:

Turning to FIGURE 8, set forth is a completed micro-assembly [80] 75 according to the teachings of the present invention. More particularly, a ribbon hinge 42 as described in the foregoing, is integrally attached at a first end to a micro-device 52 and at a second end to an anchor portion 56. Micro-device 52 includes an etched isolation region 57. Deposited within isolation region 57 is a conductive material 65 which is also deposited on ribbon hinge 42 and within an isolation groove of anchor 56. An electronic device 76 is in operational connection to the electrical conductor material 65 within isolation region 57. A power source 78 is in connection with the electrical conductor material 65, at an opposite end by anchor portion 56. Electronic device 76 may be activated upon application of electrical power from electrical power source 78. Further,

electrical device 76 may be any one of a number of devices such as an actuator to assist in movement of micro-device 52.

In the Claims

Please amend pending claims 1-8, 10 and 12-15 as follows:

1. (Amended) A hinge for use in a micro-assembly employing electrical power supplied from an electrical power source, the hinge comprising:

a silicon-on-insulator wafer including a bottom substrate layer, a middle buried oxide layer and a single crystal silicon device layer;

a ribbon hinge structure formed in the device layer of the silicon-on-insulator wafer, wherein the ribbon hinge structure is flexible and capable of movement out of the plane of the device layer; and

an electrical conductor carried on at least a portion of a surface of the ribbon hinge structure.

2. (Amended) The invention according to claim 1 wherein [the out-of-plane] a micro-device is fabricated from [a] at least a portion of the silicon-on-insulator wafer which has an initial uniform device layer thickness.

3. (Amended) The invention according to claim 1 wherein the ribbon hinge structure is configured with a mechanical integrity which permits application of a side-twisting mechanical torque sufficient to twist the ribbon hinge structure to 90° or more from an initial 0° twisted position.

4. (Amended) The invention according to claim 1 wherein the ribbon hinge structure has at least one of a width or thickness which is less than at least one of a width or thickness of the [out-of-plane] micro-device.

5. (Amended) The invention according to claim 1 wherein the ribbon [hinge] structure has at least one of (i) an isolation region formed within the ribbon [hinge] structure,

and within which is deposited the electrical conduction material, or (ii) an area of insulation material which has been deposited and then patterned on the ribbon [hinge area] structure, wherein conductors can then be placed on top of the [insulator] insulation material.

6. (Amended) A micro-assembly comprising:
a micro-device formed on or in [the] a device layer of a single crystal silicon substrate;
a ribbon [hinge] structure formed on or in the device layer, the ribbon structure having been thinned to a thickness which is less than the thickness of the micro-device;
a connection interface providing a connection point between a first end of the [out-of-plane] micro-device and a first end of the ribbon [hinge] structure; and
an electrical conductor material extending along the ribbon structure toward the micro-device.

7. (Amended) The invention according to claim 6 further including an anchor portion holding one end of the ribbon [hinge] structure in a secure position.

8. (Amended) The invention according to claim 7 where the anchor portion is formed with an isolation groove, within which is deposited [the] an isolation region of the anchor portion.

10. (Amended) The invention according to claim 6 further including an isolation region formed within the ribbon [hinge] structure, and within which is deposited the electrical conductive material.

12. (Amended) The invention according to claim 6 wherein the ribbon structure has at least one of a width or thickness which is less than at least one of a width or thickness of the [out-of-plane] micro-device.

13. (Amended) The invention according to claim 6 wherein the [out-of-plane] micro-device is fabricated from a silicon-on-insulator wafer which has an initial uniform

device layer thickness.

14. (Amended) The invention according to claim 6 wherein the ribbon [hinge] structure is configured with a mechanical integrity which permits application of a side-twisting mechanical torque to the [out-of-plane] micro-device sufficient to twist the [out-of-plane] micro-device to 90° or more from an initial 0° twisted position.

15. (Amended) The invention according to claim 6 wherein the ribbon [hinge] structure is configured with a mechanical integrity which permits application of a lifting out-of-plane mechanical torque to lift the out-of-plane device from 0° which is in the horizontal plane, to 90° or more out of the horizontal plane.

Please add new claims 16-18 as follows:

16. The invention according to claim 1, ^{wherein} the ribbon hinge structure further including:

⁵⁶ an anchor portion holding one end of the ribbon hinge in a secure position, the anchor portion formed with an isolation ⁵⁷ groove, within which is deposited the isolation region of the anchor portion,

an isolation region formed within the ribbon hinge, and within which is deposited the electrical conductive material,

the ribbon hinge structure is configured with a mechanical integrity which permits application of a side-twisting mechanical torque to the out-of-plane micro-device sufficient to twist the out-of-plane micro-device to 90° or more from an initial 0° twisted position.

17. The invention according to claim 6 further including an electronic device in operational connection to the electrical conductor material.

18. The invention according to claim 6 further including a power source in connection with the electrical conductor material.